

Interannual Variability and Decadal Change of Solar Reflectance Spectra

Zhonghai Jin, SSAI, Hampton, VA

Bruce A. Wielicki, NASA LaRC, Hampton, VA

Constantine Lukashin, SSAI, Hampton, VA

1. Objectives

- Understand the interannual variability expected in the CLARREO solar reflectance benchmark spectra to clarify the sampling requirements for CLARREO mission design.
- Compare the interannual variation with decadal climate variation to examine the ability to unscramble the climatological changes from CLARREO solar spectra.

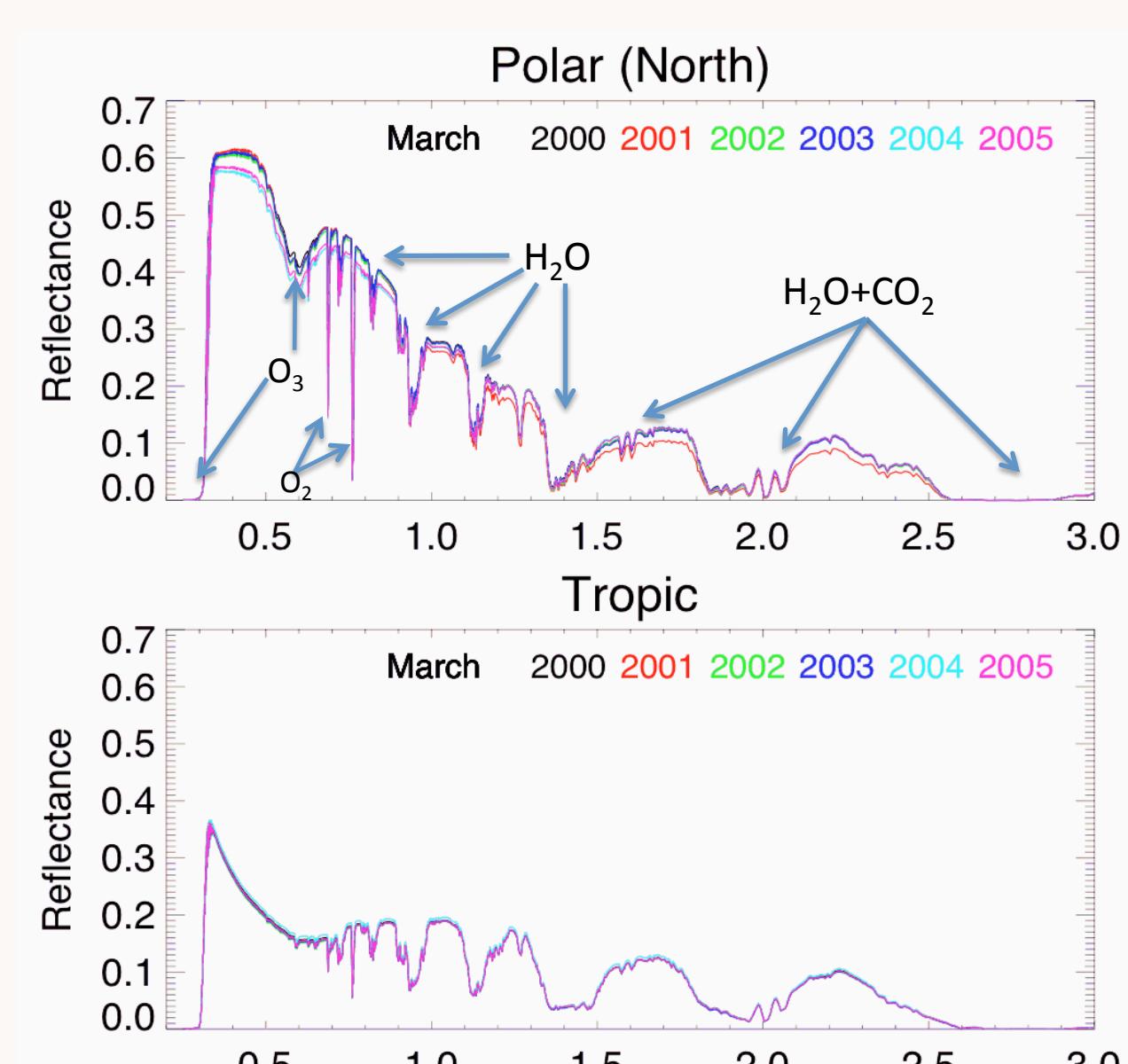


Fig 1. An example of reflectance spectra. Labeled are major absorption bands.

2. Interannual Variability of Solar Reflectance

Input parameters (monthly mean):
Aerosol/Surface properties, Cloud properties (t , RE, amount, phase), PW from CERES ARBAVG; Ozone from SMOBA

Input

6 Modtran calculations in each region each month:

- Clear open ocean
- Clear land (include sea ice)
- Water cloud ocean
- Water cloud land
- Ice cloud ocean
- Ice cloud land

Five regions:

- Polar north (>60N) (NP)
- Mid-latitude north (30N-60N) (NML)
- Tropic (30N – 30S) (TRO)
- Mid-latitude south (30S–60S) (SML)
- Polar south (> 60S) (SP)

Spectral reflectance

for 68 months (Mar 2000 to Oct 2005)
in 5 regions and global
for 0.2-5.0 μm in resolution 5 cm^{-1}
for clear sky and all sky

Table 1. Equivalent Wavelength Resolution in Nanometer (nm) for 5 cm^{-1}

$\lambda (\mu \text{m})$	Spectral Resolution (nm)		
	Modtran (5 cm^{-1})	Sciamachy	CLARREO
0.4	0.08	0.26	1.0?
0.5	0.125	0.44	?
1.0	0.5	0.54	?
2.0	2.0	1.48	?
4.0	8.0		?

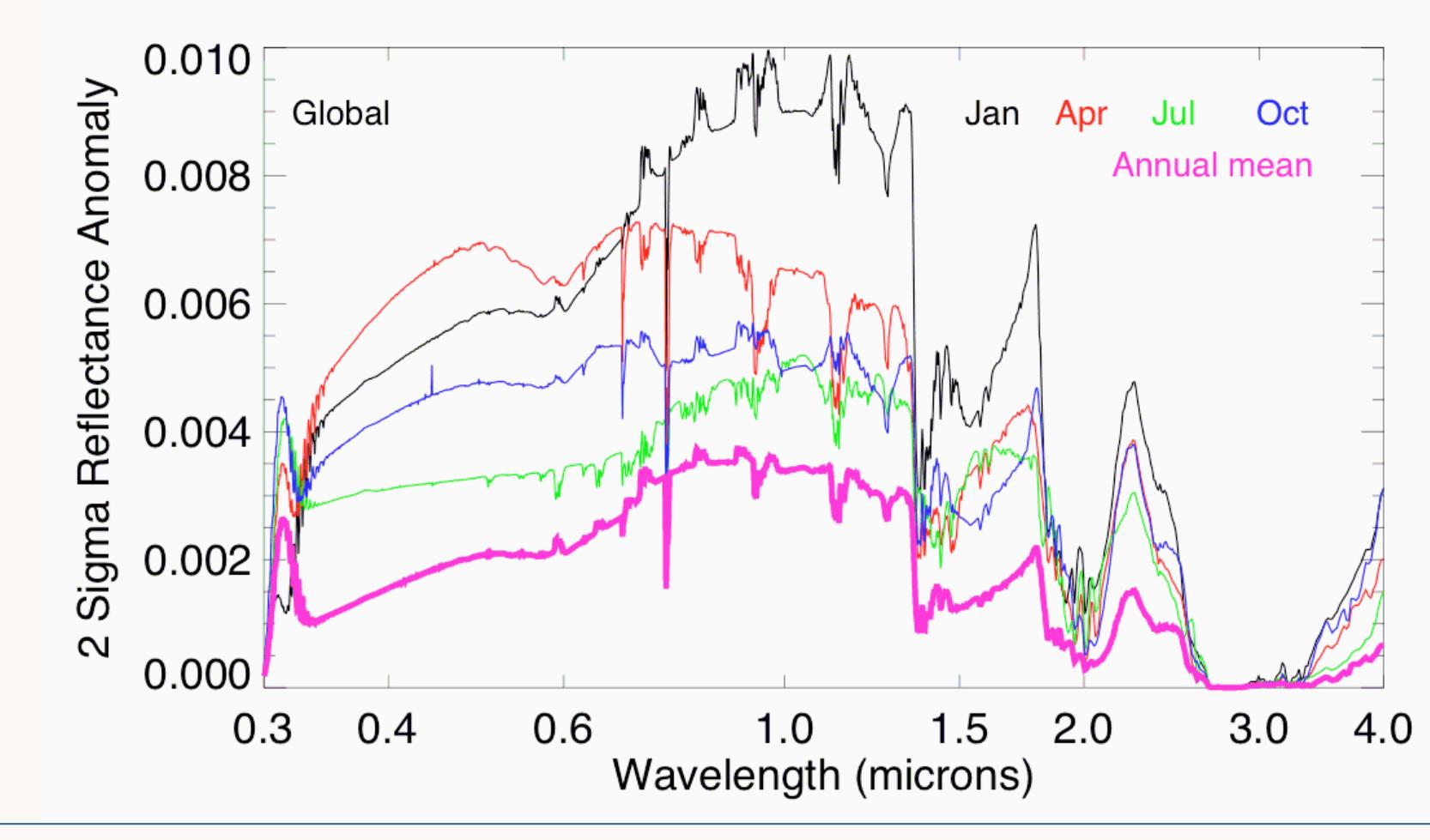


Fig 4. 2σ variation of mean reflectance. Note: annual mean is much smaller, indicating that the natural variability is dropped.

3. Climate Change of Solar Reflectance

Results above showed that the modeled interannual solar reflectance variation from CERES data is realistic.

- How this interannual variation compare to the decadal change of climate spectrum based on IPCC scenario?
- Can we unscramble the climatological changes from the CLARREO solar spectra (which include both interannual and climatological variations)?

To test these, we made two sets of simulation for 5 decades (2000-2050). The solar reflectance spectra for year 2000 are same for both (also same as that presented above) and is used as the baseline.

- The first set is to calculate the basic climate change spectra. Calculations for 5 decades (2010, 2020, 2030, 2040, 2050) all use the year 2000 inputs but add the climatological variations based on the IPCC climate change scenario (see table 2).
- The second set represents the CLARREO observation spectra. In addition to the decadal changes of input properties as in (a), the 5 year CERES data (2001-2005) are assumed for the 5 decades (i.e., 2001 CERES data for 2010, 2002 for 2020, ... etc.). So the calculated spectra include both the climatological change and the realistic interannual change.

Table 2. Decade Parameter Changes for Model Input

- CO2: +17ppm/decade increase.
- O3: No change.
- Water vapor: +1.2%/decade over ocean; 0.9% over land.
- Aerosol optical depth (AOD): no change over land; -15%/decade over ocean.
- Snow cover: -2.8%/decade in NH; no change in SH.
- Sea ice cover: -7.4/decade in NH; no change in SH.
- Surface albedo: change as (5) and (6).
- Cloud property changes as 4 cloud feedback scenario: 0.0, 0.3, 0.6 and -0.3 ($\text{w/m}^2/\text{decade}$).

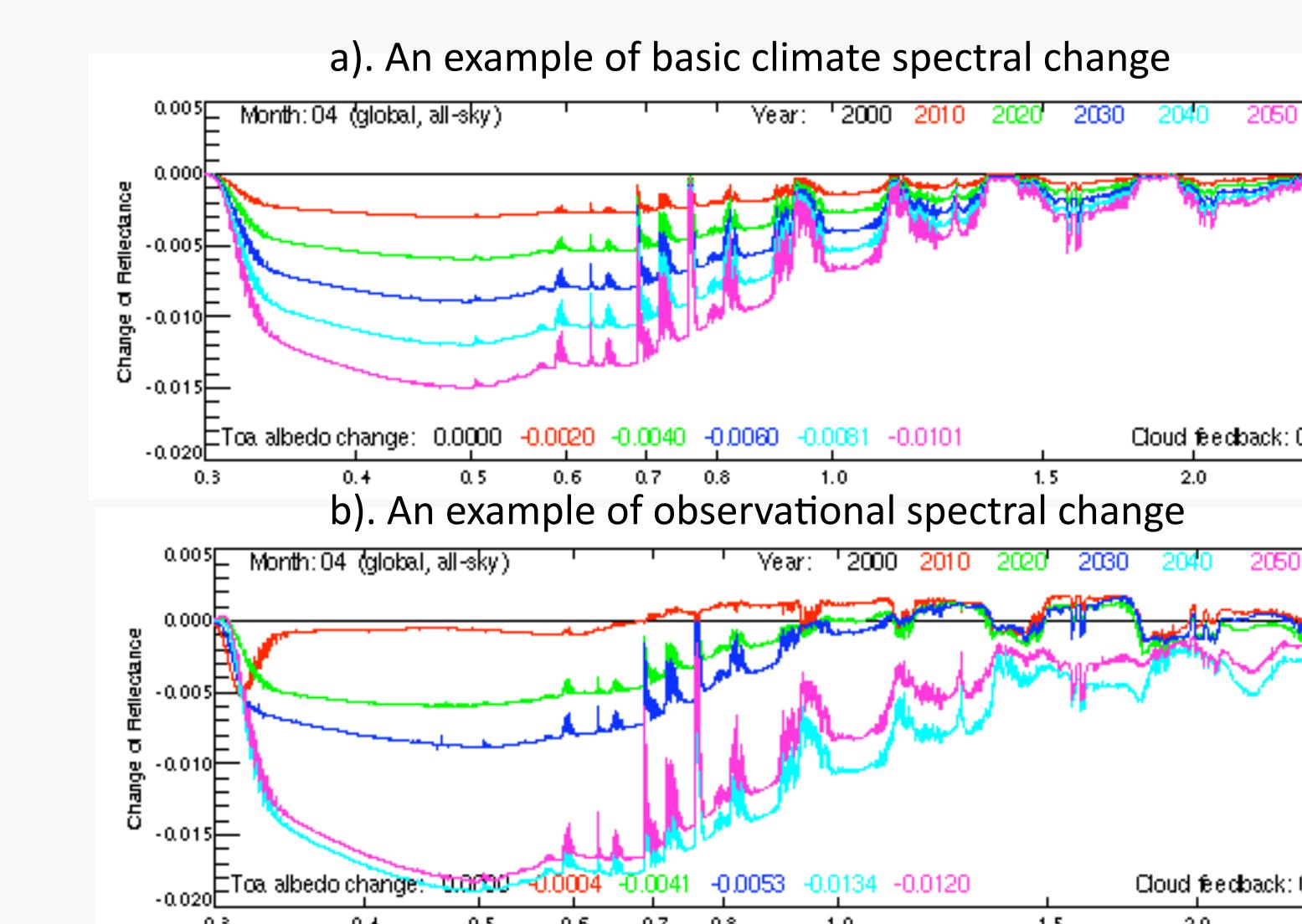


Fig 6. a). Example of the basic climate change spectra. Because the decadal input changes are small, the reflectance change is almost linear to input changes.

b). Example of the observation spectra. Because both interannual and climatological variations are included in input, the changes are not regular or linear anymore.

Can we unscramble the basic climate change (a) from observational spectra change (b)?

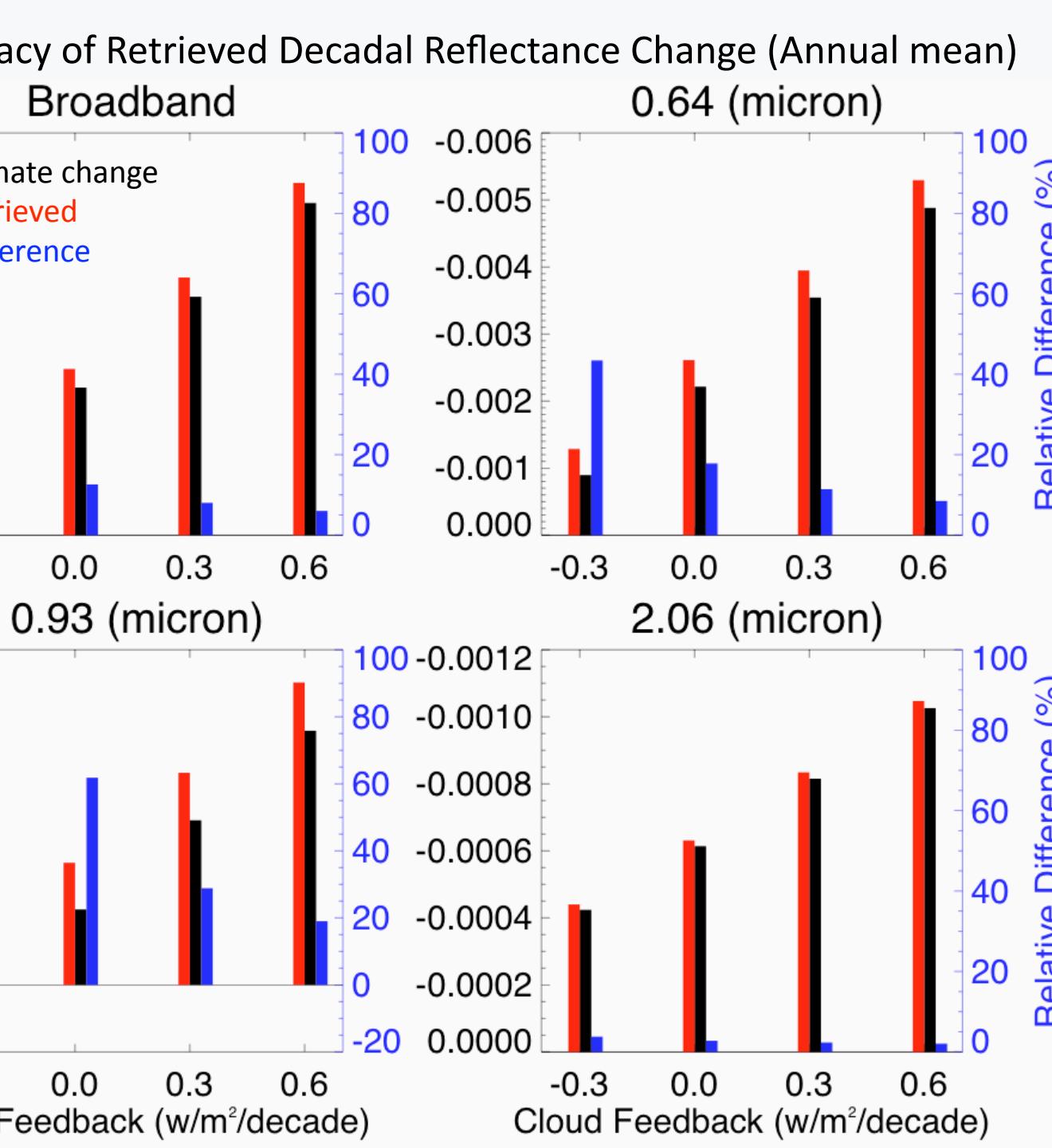


Fig 8. Examples to show the decadal changes and the recover accuracy for basic decadal climate change.

Fig 5. Reflectance anomaly compared with Sciamachy observation (global ocean). Solid line is for model, dotted line is for Sciamachy. Both show similar interannual variations and year-to-year trends.

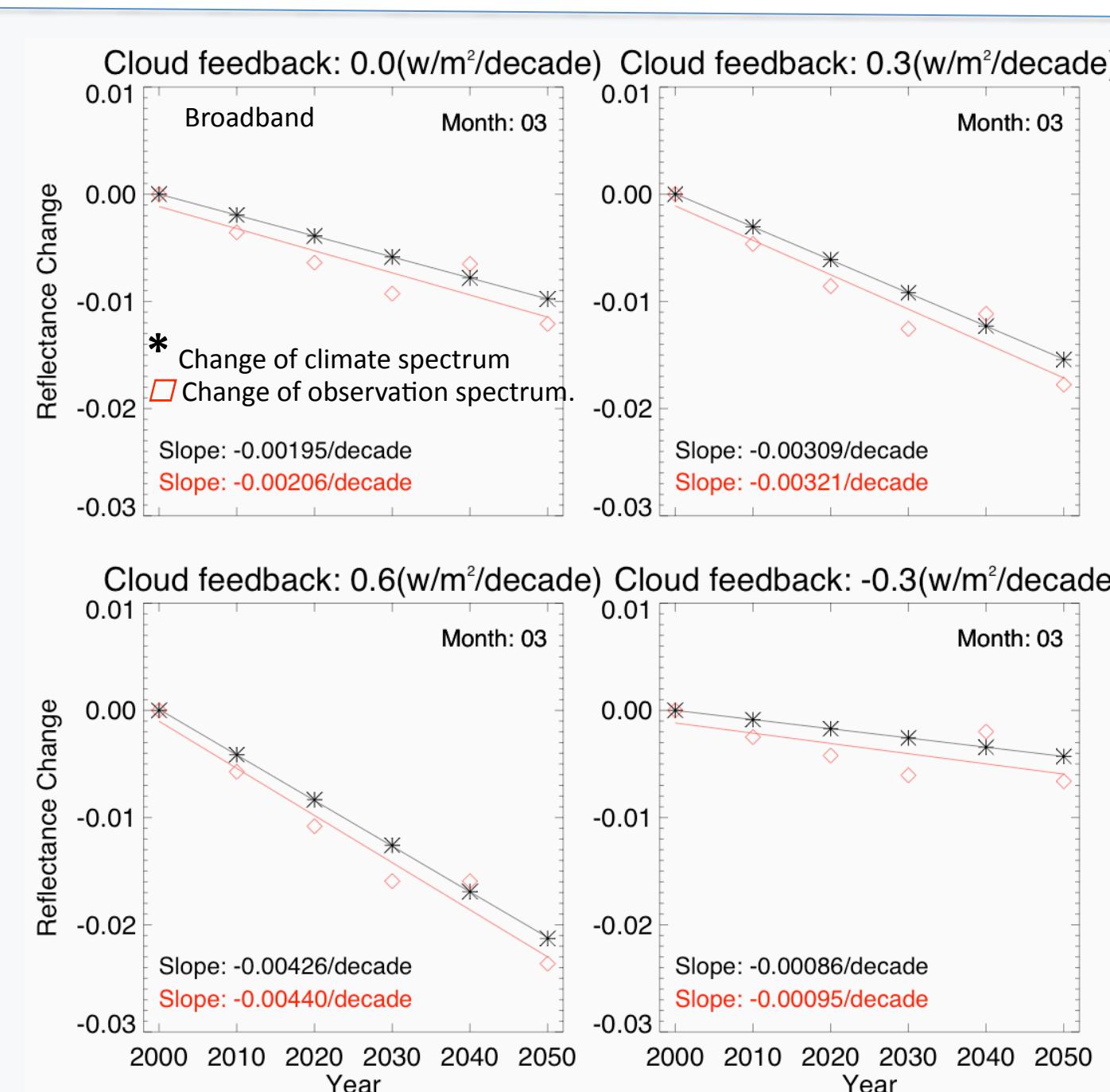
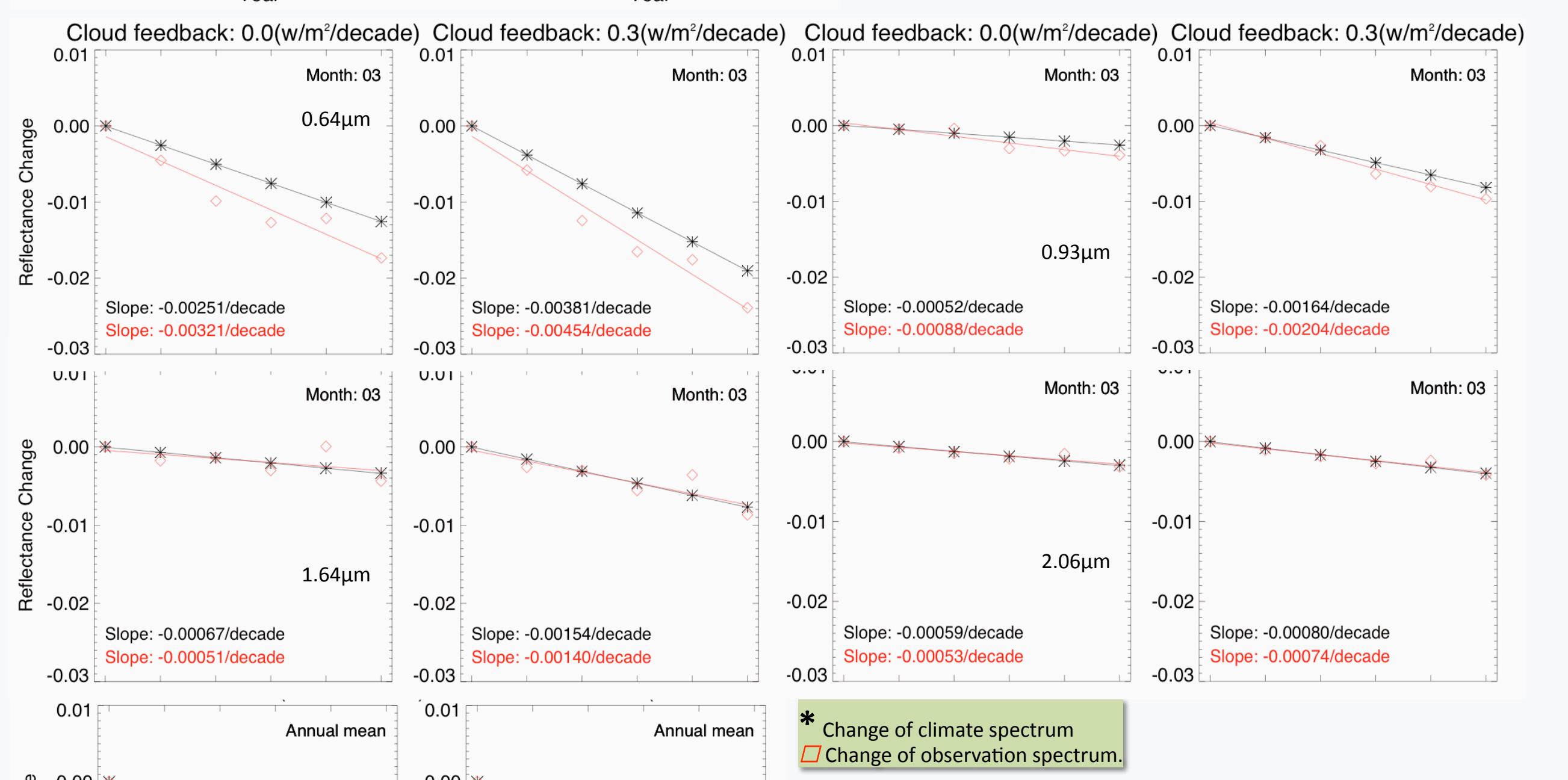


Fig 7. Examples of decadal reflectance change. The change is relative to the baseline (year 2000). The slope of each fitted line represents the decadal reflectance change. The red could be considered as the retrieved or unscrambled decadal change from observation spectra. If it equals to the black slope, the retrieval is perfect.



Note: when annual mean is used, the natural variability is much smaller (i.e., red is much closer to the line).

4. Summary

- We calculated nearly 5 years of monthly mean high resolution solar reflectance spectra for 5 regions and global.
- The reflectance anomaly for global is within 0.005 in most spectra (i.e., 1-2% of reflectance), but it is larger for polar and land regions, where have more surface variations.
- The annual, seasonal and regional variations are closely related to the variations of input parameters (clouds, aerosol, surface, water vapor and ozone ...).
- The interannual variation is comparable to the simulated decadal climate change; the ability to unscramble this climate change from CLARREO observation is tested.

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